CLIMATE CHANGE AND URBANIZATION: MINIMUM TEMPERATURE TRENDS

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Abstract:
Human influence has also led to significant regional temperature increases at the continental and subcontinental levels. Warming continued in 2016, setting a new temperature record of approximately 1.1 °C above the pre-industrial period (WMO, 2016). Understanding the long-term change of temperature events is important to the detection and attribution of climate change. However, it's unclear how much effect coming from the urbanization. In this study Adana, Kayseri, Rize, Şanlıurfa and Van have been selected as a urban station which shows the city characteristics and Akçakale, Gevaş, Karaisalı,Pazar, Pınarbaşı and Tomarza stations have been selected as rural station which shows has rural characteristics. If the population less than 100 thousand it's determined as rural area. Turkish State Meteorological Service's mean minimum temperature data with the periods 1971-2014 and Mann-Kendall rank correlation statistics for trend analysis were used. All city stations and Pazar from rural stations have showed significant increasing trends in their mean minimum temperatures. Other rural stations haven't showed increasing or decreasing trends. And also stations couples have been created between urban and rural stations by taking the differences from their mean minimum temperature. These station couples' data have also showed significant increasing trends.
Keywords: *Urbanization, mean minimum temperature, Mann-Kendall, trend*

INTRODUCTION

One of the main problems of urban residents is "urban heat island" which occurs depending on the horizontal and vertical development of cities. Formed by structuring and the increasing of impermeable surfaces, urban heat island causes cities to be hotter than the rural areas around the city (Bilgili and Sahin, 2013). "Urban heat island" was firstly defined by Luke Howard in 1820 for London, and it has been researched for several different cities in the world. Urban heat island is one of most significant climate indications of modern day civilization (Duman Yüksel and Yılmaz 2008; Bilgili and Sahin, 2013).

WMO (1983) defines urban climate as local climate that is modified by interactions between the builtup area including waste heat and the emission of air pollutants) and regional climate. The climate of a city is a local mesoclimate (spatial extension about 250 km).The city affects both physical and chemical processes in the atmospheric boundary layer (the lowest 1000 m of the atmosphere) (Mayer,1992;Fezer, 1995; WHO, 2004; Duman Yüksel and Yılmaz 2008).

Temperatures are generally higher in urban areas, exposure to heat may be greater in large cities due to the UHI effect, which may amplify the regional heat load during heatwave events. Urban heat island (UHI) is caused by many factors, including less radiant heat loss in the urban canopy layer, changes in the energy and water balances and lower wind velocities compared to rural environs (Arnfield, 2003; WMO-NO.1142). Accordingly, local and regional climates can be modified significantly by urbanization and other land-use changes.

According to population; urban stations are defined in regions having population over 500,000, and rural stations with population of less than 100,000 (Hua et al., 2007; Kındap et al., 2012)

There were many studies on effect of urbanization on climate (Çiçek, 2004, Kindap et al. 2012, Taha, 1992, Tanrıkulu, 2006, Sensoy, 2015, and Demircan 2017) in Turkey. They all investigated differences in climate between urban and rural cities with different climatological parameters such as temperature, precipitation, albedo, evapotranspiration etc. In generally they found an urbanisation effect on climate.

Urban–nonurban differences in minimum temperature serve as the primary indicator of the magnitude of the heat island effect because urban–nonurban temperature differences are normally most pronounced at night (Rosenzweig et al., 2005).

In 2016, the mean global temperature 0.94°C above the 20th century average of 14.0°C and became the warmest year since observation stated in the world. Turkey annual mean temperature in 2016 was 14.5°C. This value is 1.0°C above from 1981-2010 normal (13.5°C). 2016 was the fourth warmest year since 1971 and still 2010 is warmest year with 2.0°C above from normal.

DATA AND METHODS

We have used criteria of Hua et al., 2007 and Kındap et al., 2012 to select urban and rural stations. Urban stations have been selected in cities having population over 500,000, and rural stations with population of less than 100,000. Adana, Kayseri, Rize, Şanlıurfa and Van have been selected as a urban station which shows the urban characteristics and Akçakale, Gevaş, Karaisalı, Pazar, Pınarbaşı and Tomarza stations have been selected as rural station which shows has rural characteristics. Minimum temperature is the primary indicator of UHI (Rosenzweig et al., 2005). We have, therefore, used mean minimum temperatures of stations mentioned in above. Turkish State Meteorological Service's mean minimum temperature data with the periods 1971-2014 have used in study.
The UHI effect refers to an increase in urban air temperatures as compared to surrounding suburban and rural temperatures (Oke, 1982; Quattrochi et al., 2000). UHI effect is defined as:

$\Delta T_{u\text{-}r} = T_u - T_r$ (1)

Where; T_u is the urban station temperature, T_r is the rural station temperature, $\Delta T_{u\text{-}r}$ is the effect of UHI.

We have prepared mean minimum time series for all stations and also time series of mean minimum temperatures differences for city-rural pairs for UHI effect. City-rural pairs are Adana-Karaisalı, Kayseri-Pınarbaşı, Kayseri-Tomarza, Rize-Pazar, Şanlıurfa- Akçakale and Van-Gevaş. Mann-Kendall rank correlation statistics for trend analysis have been used for stations time series trends analysis and also time series of mean minimum temperatures differences for city-rural pairs.

APPLICATION AND RESULTS

Adana has been selected as urban station and Karaisalı has been selected as rural station for station's pair Adana-Karaisalı. The population is 2.165.595 in Adana with 7.9% increasing rate and 21.682 in Karaisalı with -24.6 decreasing rate since 2007 (URL 1). The yearly mean temperature is increasing in both station according to 1971 and there is a difference between stations' temperature (Fig. 1). While there is a significant increasing trend in mean minimum temperatures of Adana, there is not increasing or decreasing trend in Karaisalı's mean minimum temperatures (Figure 2; Table 1; Table 1). Mean minimum temperatures difference of Adana-Karaisalı pair is showed an increasing trend with 95% of statistically significant level (Table 1; Table 2).

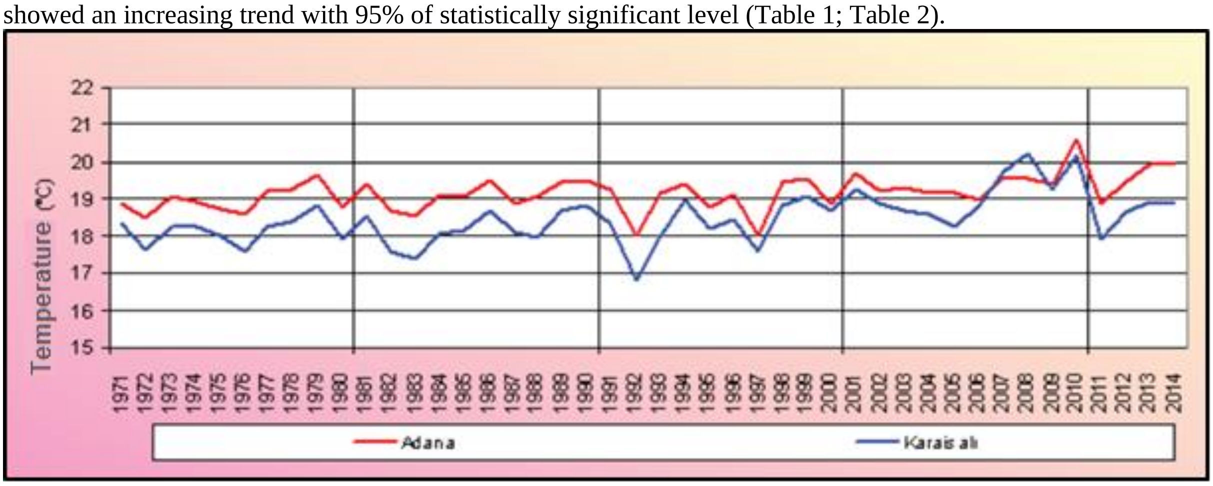

Figure 1. Time series of mean temperatures of Adana and Karaisali.

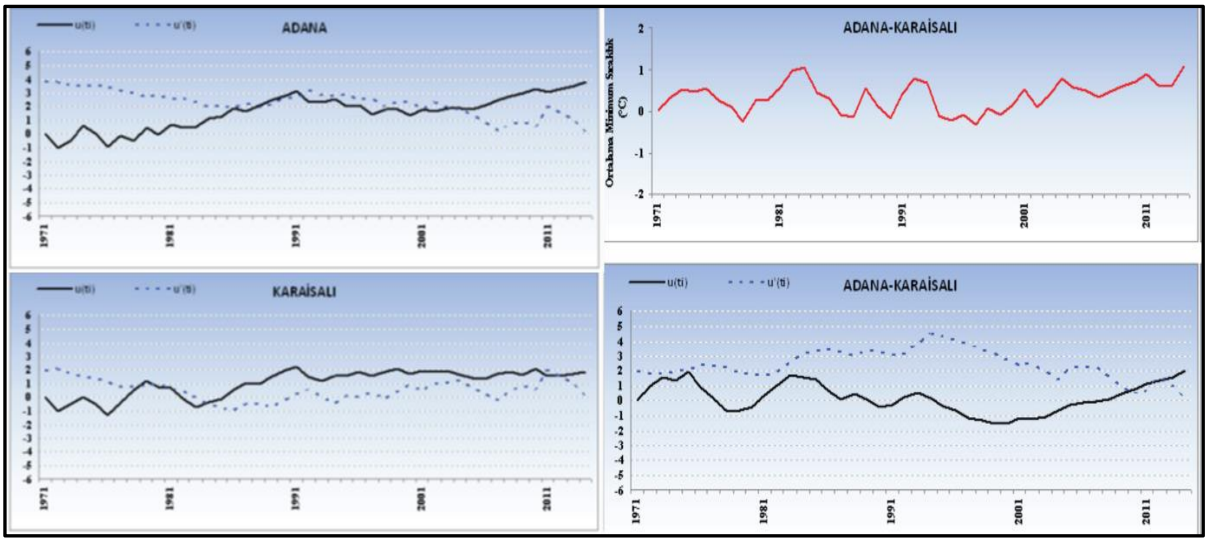

Figure 2. Mann-Kendal graphics for mean minimum temperatures of Adana and Karaisalı (on the left), mean minimum temperatures difference of Adana-Karaisalı pair (on right upper) and Mann-Kendal graphic for mean minimum temperatures difference of Adana-Karaisalı pair (on right bottom)

Table 1. Mann-Kendal result for mean minimum temperatures of Adana and Karaisalı. (*statistically significant)

Station Name	Mann-Kendall Test
Adana	3,80*
Karaisalı	1,88

Table 2. Mann-Kendal result for mean minimum temperatures difference of Adana-Karaisalı pair

Station's Pair	Mann-Kendall Test
Adana–Karaisalı	2,00*

Kayseri has been selected as urban station. Pınarbaşı and Tomarza have been selected as rural station for station's pairs Kayseri-Pınarbaşı and Kayseri-Tomarza. The population is 1.322.376 in Kayseri with 13.5% increasing rate and 25.293 in Pınarbaşı with -15.9 decreasing rate and 24.131 in Tomarza with -11.9 decreasing rate since 2007 (URL 1). The yearly mean temperature is increasing in all station according to 1971 and there is a difference between urban and rural stations' temperature while two rural stations' temperatures are too close (Fig. 3). While there is a significant increasing trend in mean minimum temperatures of Kayseri, there are not increasing or decreasing trend in mean minimum temperatures of Pınarbaşı and Tomarza (Fig. 4; Table 3). Mean minimum temperatures difference of Kayseri-Pınarbaşı and Kayseri-Tomarza pairs are showed an increasing trend with 95% of significant level (Fig. 4; Table 4).

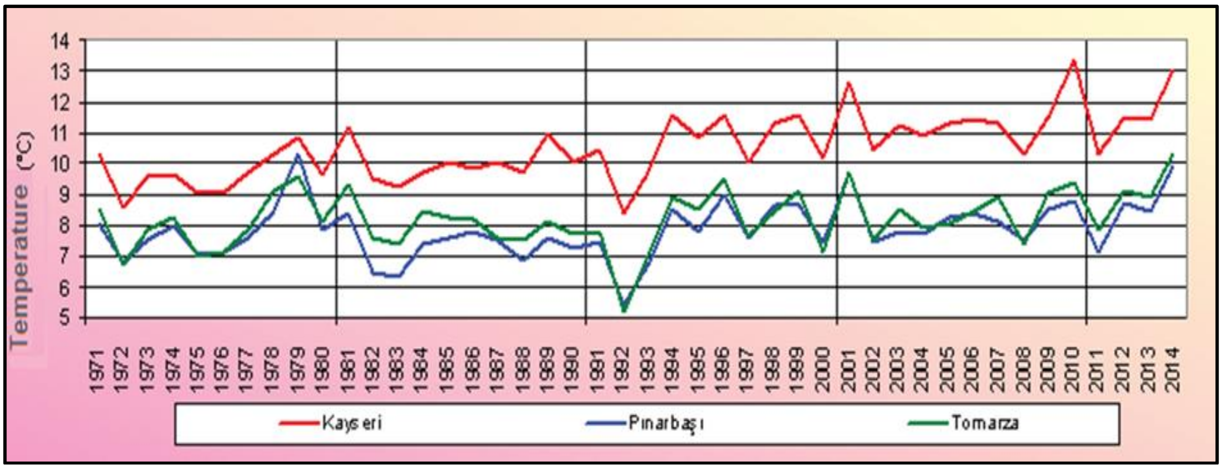

Figure 3. Time series of mean temperatures of Kayseri, Pınarbaşı and Tomarza

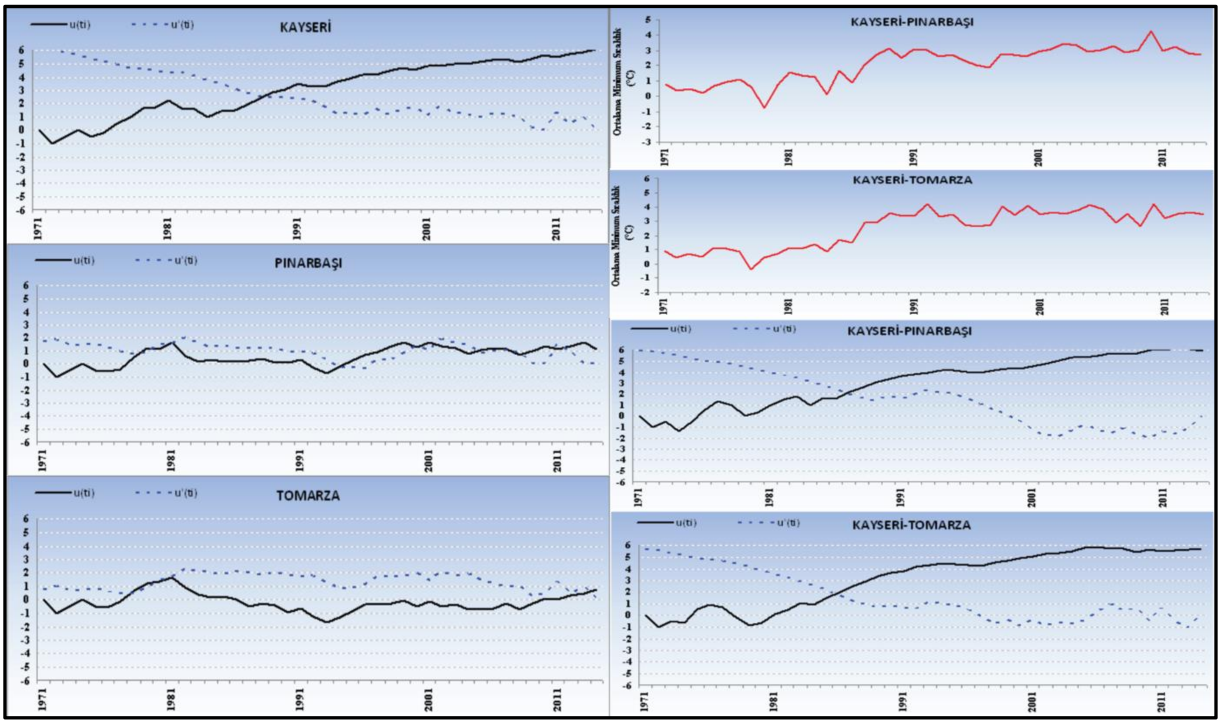

Figure 4. Mann-Kendal graphics for mean minimum temperatures of Kayseri, Pınarbaşı and Tomarza (on the left), mean minimum temperatures difference of Kayseri-Pınarbaşı and Kayseri- Tomarza pair (on right upper) and Mann-Kendal graphic for mean minimum temperatures difference of Kayseri and Pınarbaşı pair and Mann-Kendal graphic for mean minimum temperatures difference of Kayseri and Tomarza pair (on right bottom)

Table 3. Mann-Kendal result for mean minimum temperatures of Kayseri, Pınarbaşı and Tomarza. (*statistically significant)

Station Name	Mann-Kendall Test
Kayseri	6,05*
Pınarbaşı	1,66
Tomarza	0,77

Table 4. Mann-Kendal result for mean minimum temperatures difference of Kayseri-Pınarbaşı and Kayseri-Tomarza pairs

Station's Pairs	Mann-Kendall Test
Kayseri–Pınarbaşı	5,91*
Kayseri–Tomarza	5,62*

Rize has been selected as urban station and Pazar has been selected as rural station for station's pair Rize-Pazar. The population is 329.779 in Rize with 4.3% increasing rate and 30.824 in Pazar with a slightly decreasing rate since 2007 (URL 1). The yearly mean temperature is increasing in both station according to 1971 and there is a difference between stations' temperature (Fig. 5).There are significant increasing trend in both of mean minimum temperatures of Rize and Pazar. However Rize's trend is higher than Pazar's trend (Fig. 6;Table 5). Mean minimum temperatures difference of Rize-Pazar pair is showed a significant increasing trend with 95% of significant level (Fig. 6; Table 6).

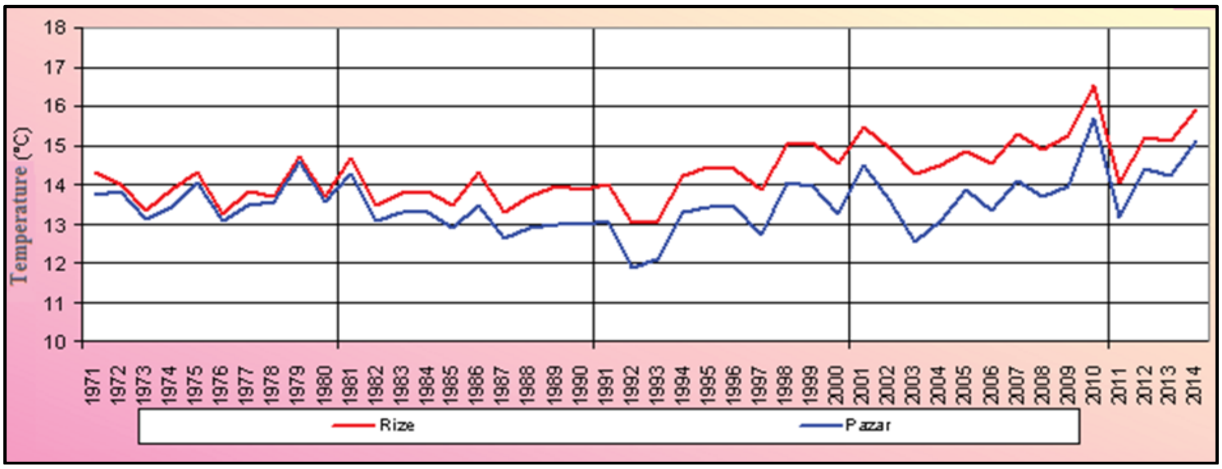

Figure 5. Time series of mean temperatures of Rize and Pazar.

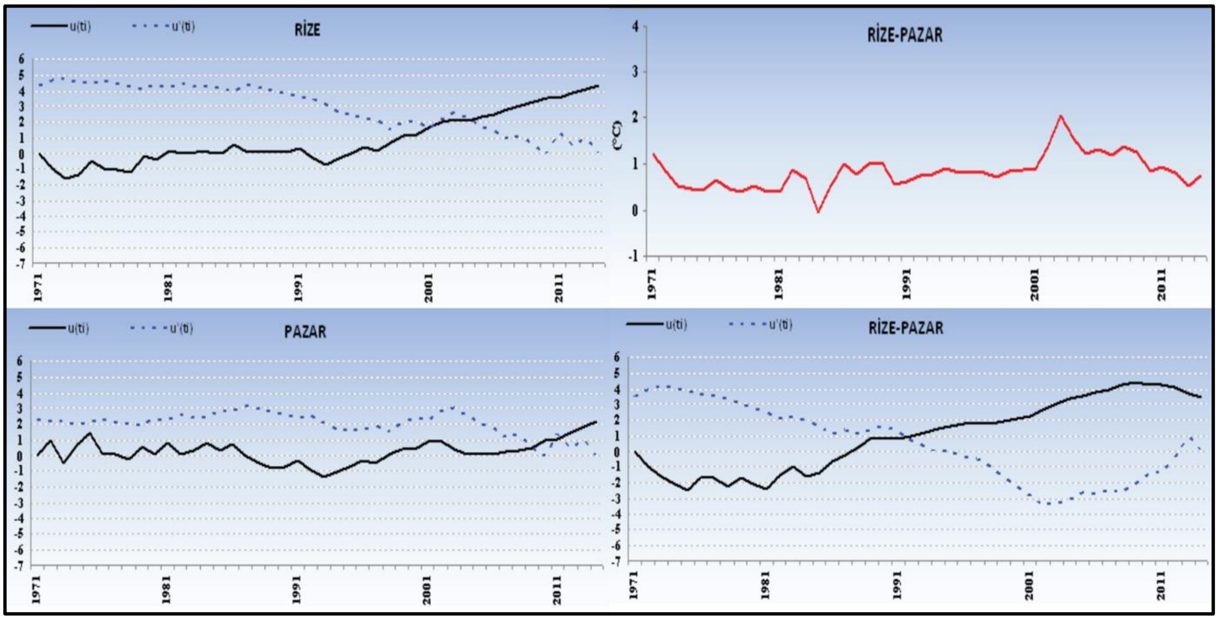

Figure 6. Mann-Kendal graphics for mean minimum temperatures of Rize and Pazar (on the left), mean minimum temperatures difference of Rize and Pazar pair (on right upper) and Mann-Kendal graphic for mean minimum temperatures difference of Rize and Pazar pair (on right bottom)

Table 5. Mann-Kendal result for mean minimum temperatures of Rize and Pazar. (*statistically significant)

Station Name	Mann-Kendall Test
Rize	4,37*
Pazar	2,18*

Table 6. Mann-Kendal result for mean minimum temperatures difference of station's Rize-Pazar pair.

Station's Pair	Mann-Kendall Test
Rize–Pazar	3,48*

Şanlıurfa has selected as urban station and Akçakale has selected as rural station for station's pair Şanlıurfa-Akçakale. The population is 1.845.667 in Şanlıurfa with 21.2% increasing rate and 98.897 in Akçakale with 28.8 increasing rate since 2007 (URL 1). The yearly mean temperature is increasing in both station according to 1971 and there is a difference between stations' temperature (Fig. 7). While there is a significant increasing trend in mean minimum temperatures of Şanlıurfa, there is not increasing or decreasing trend in Akçakale's mean minimum temperatures (Fig. 8; Table 7). Mean minimum temperatures difference of Şanlıurfa-Akçakale pair is showed a significant increasing trend with 95% of significant level (Fig. 8; Table 8).

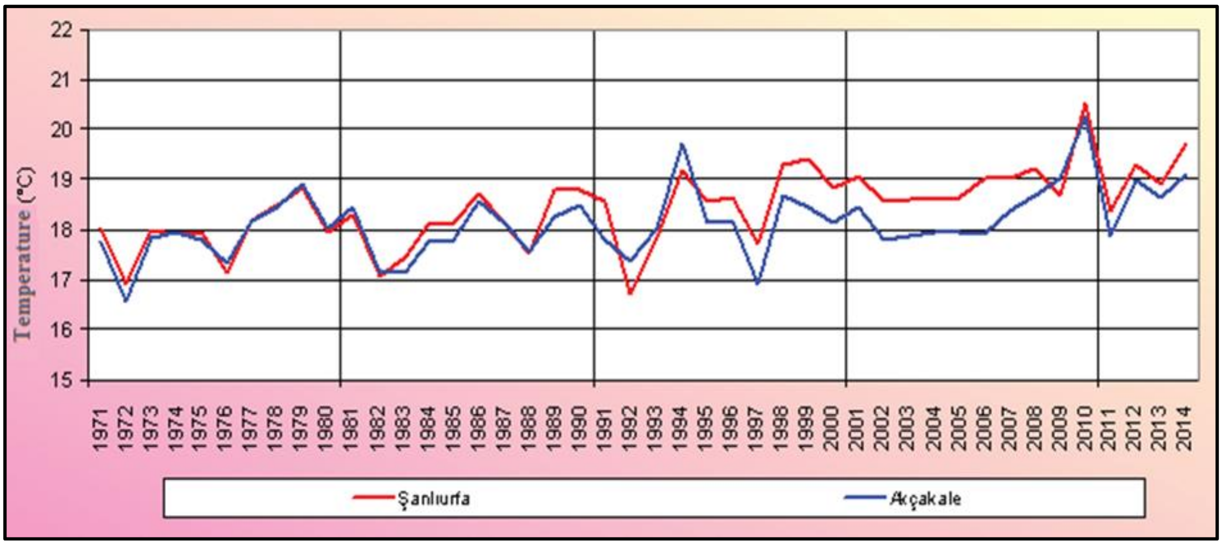

Figure 7. Time series of mean temperatures of Şanlıurfa and Akçakale

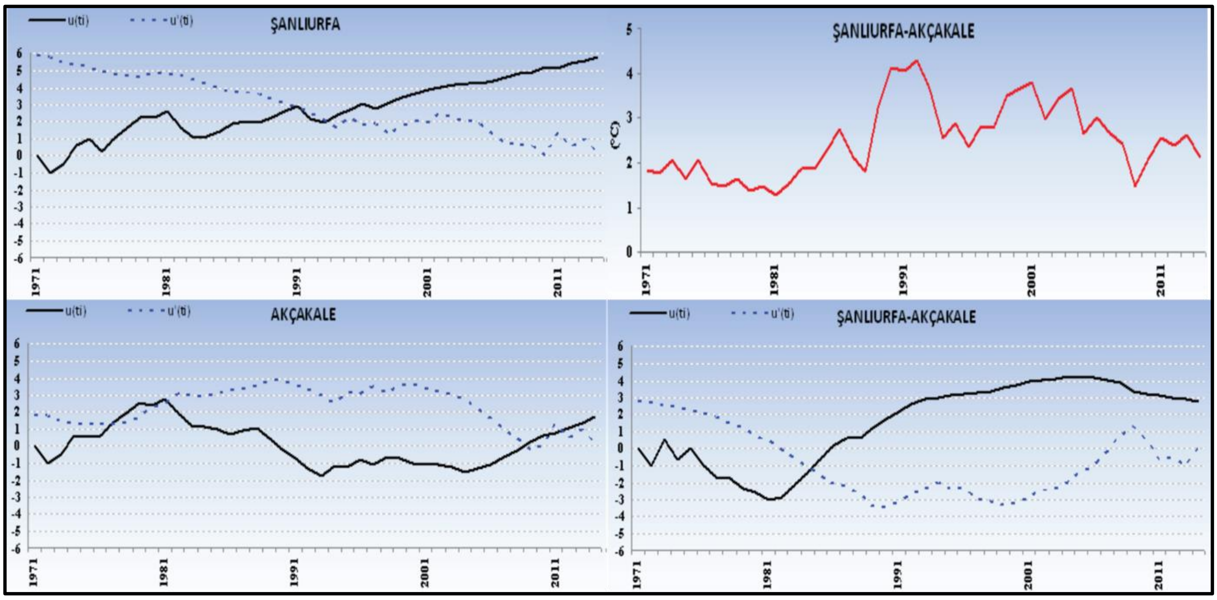

Figure 8. Mann-Kendal graphics for mean minimum temperatures of Şanlıurfa and Akçakale (on the left), mean minimum temperatures difference of Şanlıurfa and Akçakale pair (on right upper) and Mann-Kendal graphic for mean minimum temperatures difference of Şanlıurfa and Akçakale pair (on right bottom)

Table 7. Mann-Kendal result for mean minimum temperatures of Şanlıurfa and Akçakale. (*statistically significant)

Station Name	Mann-Kendall Test
Şanlıurfa	5,79*
Akçakale	1,76

Table 8. Mann-Kendal result for mean minimum temperatures difference of Şanlıurfa-Akçakale pair

Station's Pair	Mann-Kendall Test
Şanlıurfa–Akçakale	2,75*

Van has selected as urban station and Gevaş has selected as rural station for station's pair Van-Gevaş. The population is 1.085.542 in Van with 10.8% increasing rate and 28.982 in Gevaş with -2.7 decreasing rate since 2007 (URL 1). The yearly mean temperature is increasing in both station according to 1971 and there is a difference between stations' temperature (Fig. 9). While there is a significant increasing trend in mean minimum temperatures of Van, there is not increasing or decreasing trend in Gevaş's mean minimum temperatures (Fig. 10; Table 9). Mean minimum temperatures difference of Van-Gevaş pair is showed a significant increasing trend with 95% of significant level (Fig. 10; Table 10).

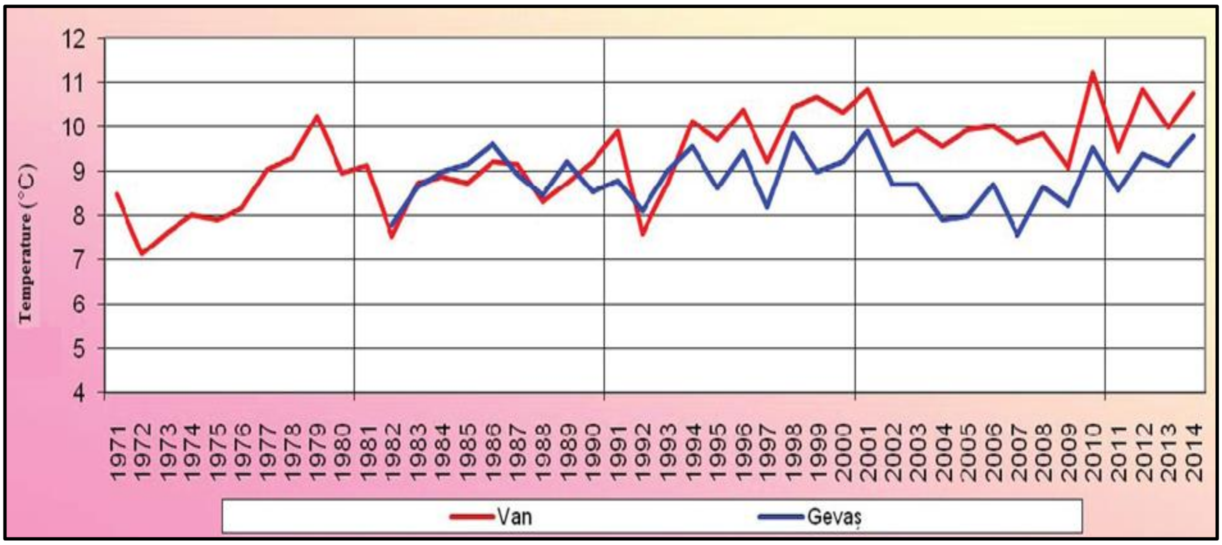

Figure 9. Time series of mean temperatures of Van and Gevaş.

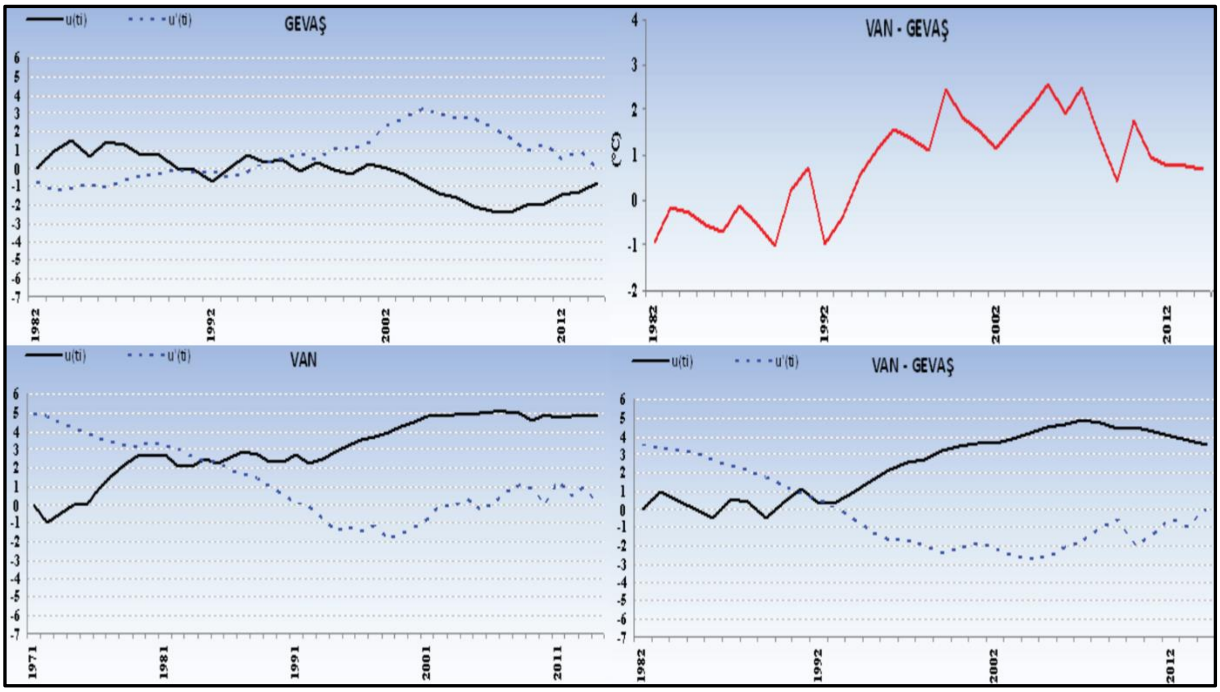

Figure 10. Mann-Kendal grafics for mean minimum temperatures of Van and Gevaş (on the left), mean minimum temperatures difference of Van and Gevaş pair (on right upper) and Mann-Kendal graphic for mean minimum temperatures difference of Van and Gevaş pair (on right bottom)

Table 9. Mann-Kendal result for mean minimum temperatures of Van and Gevaş. (*statistically significant)

Station Name	Mann-Kendall Test
Van	4,90*
Gevaş	-0,81

Table 10. Mann-Kendal result for mean minimum temperatures difference of Van-Gevaş pair

Station's Pair	Mann-Kendall Test
Van–Gevaş	3,56*

CONCLUSIONS AND RECOMMENDATIONS

Global temperature has risen caused by climate change due to greenhouse gases produced by human activities in last century on Earth. In a similar manner, temperature has also risen in Turkey. However, increase in temperature is not same in everywhere as well as between cities and rural. Human activities is one of the important force to change land use and land cover in Earth to be categorized in either urbanization or cultivation. Urbans are the best sample to these due to vegetation-cover are replaced with highly impervious reconstruction in cities such as asphalts, concrete, and building. Furthermore, urban facilities are absorbing solar energy during the day and emitting during the night and thus preventing cooling in the cities surface and atmosphere.

Urban–nonurban differences in minimum temperature serve as the primary indicator of the magnitude of the heat island effect because urban–nonurban temperature differences are normally most pronounced at night (Rosenzweig et al., 2005).

In this study, urbanization effects on the mean minimum temperature trends are investigated at the selected stations which are Adana, Kayseri, Rize, Şanlıurfa and Van as urban stations and Akçakale, Gevaş, Karaisalı, Pazar, Pınarbaşı and Tomarza as rural stations for the period between. Urban stations have been selected in cities having population over 500,000, and rural stations with population of less than 100,000. While selected urbans' populations are increasing rural settlements' populations are decreasing except Akçakale. We aim to quantify the UHI effect by contrasting the temperatures between urban–rural areas and to this end we study on mean minimum time series for all stations and also time series of mean minimum temperatures differences for urban-rural pairs for UHI effect.

Due to climate change and rising temperature in the Earth, in parallel with this, mean temperatures of selected stations are increasing with difference between urban and rural stations. It is assumed that these differences caused by urbanization. This study's findings suggest that there is no statistically significant increase in rural mean minimum temperatures trends except Pazar for the period between 1971 and 2014. However, all the urban sites show statistically significant increase in mean minimum temperatures trends. Furthermore, urban-rural pairs show statistically significant increase in mean minimum temperatures trends. We assumed that this is a strong indication for the existence of UHI effect over these cities.

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